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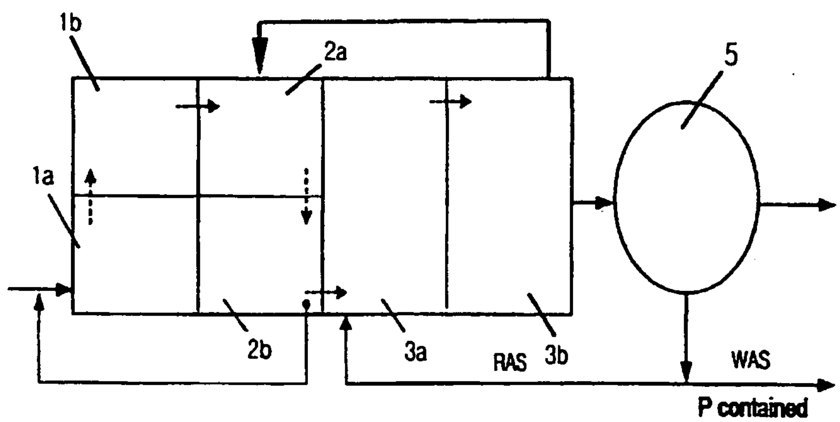
(54) Title: APPARATUS AND METHOD FOR PURIFYING WASTEWATER



(57) Abstract: The present invention provides an apparatus for purifying wastewater comprising: an anaerobic tank (1) for treating the wastewater with anaerobic bacteria; an anoxic tank (2) for treating the wastewater from the anaerobic tank (1) with denitrifying bacteria and then returning part of the wastewater to the anaerobic tank (1); an aerobic tank (3) for treating the wastewater from the anoxic tank (2) with aerobic bacteria and then returning part of the wastewater to the anoxic tank (2); and a clarifier (5) for settling the wastewater from the aerobic tank (3), discharging a purified water, and returning part of a sediment to the aerobic tank (3) through a return line (6). Besides, the present invention provides an apparatus for purifying wastewater, which has an anaerobic tank, an anoxic tank, an aerobic tank, and a clarifier, comprising a dissolved oxygen lowering tank for receiving the wastewater returned from the aerobic tank positioned after the anoxic tank and part of the wastewater from a zone positioned before the anoxic tank to decrease the dissolved oxygen, and then introducing the received wastewaters into the anoxic tank.

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APPARATUS AND METHOD FOR PURIFYING WASTEWATER

Technical Field

The present invention relates to an apparatus and method for purifying wastewater by biological advanced treatment of wastewater. More particularly, the present invention relates to an apparatus for purifying wastewater being newly organized to maximize the wastewater purification efficiency which has an anaerobic tank, an anoxic tank, an aerobic tank and a clarifier, and a method for purifying wastewater using the same.

Background Art

A conventional wastewater purification apparatus and method comprises a single tank, for example, aerobic tank. The wastewater treated at the aerobic tank is settled in a clarifier and then discharged. Such a conventional wastewater purification apparatus and method, however, has a low efficiency in the removal of nitrogen, phosphorus and organisms and thus, the purified wastewater discharged into the river adversely causes eutrophication.

In an attempt to solve the problem, there have been suggested various improved wastewater purification methods, for example, A2/O method, Bardenpho method, UCT method, and the like. These methods or modifications thereof are

reported to improve the wastewater purification efficiency to some extent.

For instance, the A2/O method, known as a representative method for biological removal of nitrogen and phosphorus, has an anaerobic tank and an anoxic tank sequentially arranged before an aerobic tank. The wastewater treated at the aerobic tank is returned to the anoxic tank to eliminate nitrate nitrogen. A part of the active sludge settled in a clarifier is returned to the anaerobic tank not only to maintain the concentration of the microorganism in all the tanks but also to eliminate phosphorus by releasing phosphorus at the anaerobic tank and absorbing an excess of phosphorus at the subsequent aerobic tank.

However, the A2/O method also returns dissolved oxygen as well as the wastewater treated in the aerobic tank to the anoxic tank. Thus, the nitrogen removal efficiency in the anoxic tank is adversely deteriorated.

In addition, while a part of the active sludge settled in the clarifier is returned into the anaerobic tank, nitrate nitrogen is also returned. Therefore, the release of phosphorus is inhibited in the anaerobic tank and the phosphorus removal efficiency is thereby deteriorated. Furthermore, the deterioration of the nitrogen removal efficiency in the anoxic tank as described above causes the concentration of returned nitrate to increase, which results in further deterioration of the phosphorus removal efficiency.

The anaerobic tank and the anoxic tank in the A2/O method have a structure inadequate for inducing endogenous respiration of the microorganism and cause low wastewater purification efficiency.

Furthermore, in order to apply the A2/O method to the conventional wastewater treatment apparatus having an aerobic tank alone, it is required to arrange an anaerobic tank and an anoxic tank before the aerobic tank and install an active sludge return line from a clarifier to the anaerobic tank. This arrangement inevitably requires long-term operational interruption of the wastewater purification apparatus as well as much labors and costs.

Disclosure of the Invention

It is an object of the present invention to solve the problem in the prior art and to provide a wastewater purification apparatus and method capable of achieving high wastewater purification efficiency with a simple arrangement.

It is another object of the present invention to provide a wastewater purification apparatus and method that allows additional arrangement of an anaerobic tank and an anoxic tank without changing an active sludge return line in the conventional wastewater treatment apparatus comprising an aerobic tank alone, and hardly requires operational interruption of the wastewater purification apparatus.

It is still another object of the present invention to provide a wastewater purification apparatus and method that returns the wastewater from a clarifier to an aerobic tank to maintain high MLSS level in the aerobic tank and hence high nitration efficiency at a low water temperature in winter and thereby reduce the TN level of the purified wastewater.

It is still further another object of the present invention to provide a wastewater purification apparatus and method that lowers the dissolved oxygen in a returned wastewater from an aerobic tank to an anoxic tank, thereby enhancing the treatment efficiency in the anoxic tank.

It is still further another object of the present invention to enhance the rate of lowering the dissolved oxygen to minimize the volume of a dissolved oxygen lowering tank.

It is still further another object of the present invention to enable optimized endogenous respiration of the microorganism in the anaerobic and anoxic tanks, thereby enhancing the total wastewater purification efficiency.

It is still further another object of the present invention to provide a wastewater purification apparatus and method that can be interchangeably applied to various wastewater purification apparatuses having an anaerobic tank, an anoxic tank and an aerobic tank.

To achieve the above objects of the present invention, there is provided an apparatus for purifying wastewater

comprising: an anaerobic tank 1 for treating the wastewater with anaerobic bacteria; an anoxic tank 2 for treating the wastewater from the anaerobic tank 1 with denitrifying bacteria and then returning part of the wastewater to the anaerobic tank 1; an aerobic tank 3 for treating the wastewater from the anoxic tank 2 with aerobic bacteria and then returning part of the wastewater to the anoxic tank 2; and a clarifier 5 for settling the wastewater from the aerobic tank 3, discharging a purified water, and returning part of a sediment to the aerobic tank 3 through a return line 6.

Preferably, the anaerobic tank, the anoxic tank and the aerobic tank are formed by arranging partition walls with a PE panel in a single tank.

Preferably, the wastewater returned from the aerobic tank 3 to the anoxic tank 2 is introduced in halfway into a dissolved oxygen lowering tank 4 to decrease the dissolved oxygen, and then returned to the anoxic tank 2.

Preferably, part of the wastewater prior to entering the anaerobic tank or part of the wastewater from the anaerobic tank is additionally introduced into the dissolved oxygen lowering tank 4.

In another aspect of the present invention, there is provided an apparatus for purifying wastewater, which has an anaerobic tank, an anoxic tank, an aerobic tank, and a clarifier, comprising a dissolved oxygen lowering tank for receiving the

wastewater returned from the aerobic tank positioned after the anoxic tank and part of the wastewater from a zone positioned before the anoxic tank to decrease the dissolved oxygen, and then introducing the received wastewaters into the anoxic tank.

Preferably, the wastewater from the zone positioned before the anoxic tank is at least one of the raw wastewater and the wastewater from the anaerobic tank positioned before the anoxic tank.

Preferably, the anaerobic tank positioned before the anoxic tank and the anoxic tank have a wastewater return line for returning part of the wastewater from the anoxic tank to the anaerobic tank positioned before the anoxic tank, wherein the aerobic tank after the anoxic tank and the clarifier positioned after the anoxic tank have a sludge return line for returning part of the sediment from the clarifier positioned after the anoxic tank to the aerobic tank positioned after the anoxic tank.

Preferably, nozzles are arranged at an inlet through which the wastewater from the dissolved oxygen lowering tank 4 is introduced into the anoxic tank.

Preferably, a plurality of separate walls are vertically provided in zigzag inside the anaerobic tank and the anoxic tank, wherein each of the separate walls has one side thereof being in close contact with one side wall of the anaerobic tank or the anoxic tank, and the other side thereof being apart from the other side wall of the anaerobic tank or the anoxic tank, thereby

causing a plug flow of the wastewater in the anaerobic tank and the anoxic tank.

Preferably, the dissolved oxygen lowering tank or the separate walls are manufactured by fixing PE panel fixing angles in the inner side wall of the aerobic tank 3, the anaerobic tank 3 or the anoxic tank 2, inserting a PE panel between the PE panel fixing angles, and then caulking a joint.

Preferably, the PE panel is formed by connecting a plurality of PE panel pieces.

In further another aspect of the present invention, there is provided a method for purifying wastewater comprising the steps of: treating the wastewater introduced into an anaerobic tank with anaerobic bacteria; introducing the wastewater from the anaerobic tank into an anoxic tank for treatment with denitrifying bacteria, and then returning part of the wastewater to the anaerobic tank; introducing the wastewater from the anoxic tank into an aerobic tank for treatment with aerobic bacteria, and then returning part of the wastewater to the anoxic tank; and settling the wastewater from the aerobic tank, and returning part of a sediment to the aerobic tank.

Preferably, the wastewater returned from the aerobic tank 3 to the anoxic tank 2 is introduced in halfway into a dissolved oxygen lowering tank 4 to decrease the dissolved oxygen, and then returned to the anoxic tank 2.

In further another aspect of the present invention, there is

provided a method for purifying wastewater, which is to treat the wastewater using an apparatus for purifying wastewater having an anaerobic tank, an anoxic tank, an aerobic tank, and a clarifier, the method comprising the steps of: introducing, into a dissolved oxygen lowering tank, part of the wastewater from a zone positioned before the anoxic tank and the returned wastewater from the aerobic tank positioned after the anoxic tank to decrease the dissolved oxygen; and introducing the wastewater from the dissolved oxygen lowering tank into the anoxic tank.

Brief Description of the Drawings

FIG. 1 is a plan view of a wastewater purification apparatus according to a preferred embodiment of the present invention;

FIG.2 is a plan view for illustrating a dissolved oxygen lowering tank according to a preferred embodiment of the present invention, which is applied to the wastewater purification apparatus shown in FIG. 1;

FIG. 3 is a plan view for illustrating a dissolved oxygen lowering tank according to another preferred embodiment of the present invention;

FIG. 4 is a plan view for illustrating the dissolved oxygen lowering tank shown in FIG. 3 applied to the wastewater purification apparatus shown in FIG. 1 according to another

preferred embodiment of the present invention;

FIGS. 5a and 5b are diagrams showing the results of an experiment performed to measure the dissolved oxygen lowering characteristic in the dissolved oxygen lowering tank of the wastewater purification apparatus shown in FIG. 2, in which

FIG. 5a shows the dissolved oxygen lowering characteristic of the wastewater returned into the aerobic tank in which the initial substrate still remains; and

FIG. 5b shows the dissolved oxygen lowering characteristic of the wastewater returned into the aerobic tank after the substrate is completely oxidized;

FIGS. 6a to 6j are diagrams showing the results of an experiment performed to measure the dissolved oxygen lowering characteristic in the dissolved oxygen lowering tank of the wastewater purification apparatus shown in FIG. 4, while varying the mixing ratio of the wastewater from the anaerobic tank and the wastewater returned from the aerobic tank;

FIGS. 7 to 12 are schematic plan views of a wastewater purification apparatus equipped with the dissolved oxygen lowering tank shown in FIG. 3 according to further another preferred embodiment of the present invention;

FIG. 13 is a schematic plan view of a wastewater purification apparatus having separate walls according to further another preferred embodiment of the present invention;

FIG. 14 is a plan view of a wastewater purification

apparatus shown in FIG. 2 having separate walls according to further another preferred embodiment of the present invention; and

FIGS. 15a and 15b are schematic views showing a method for mounting a PE panel constituting the separate walls, the dissolved oxygen lowering tanks and partition walls according to further another preferred embodiment of the present invention.

Best Mode For Carrying Out The Invention

FIG. 1 is a plan view of a wastewater purification apparatus according to a preferred embodiment of the present invention.

The wastewater purification apparatus shown in FIG. 1 comprises an anaerobic tank 1, an anoxic tank 2, an aerobic tank 3, and a clarifier 5 in a similar way to the conventional wastewater purification apparatus using the A2/O method. The anaerobic tank comprises first and second anaerobic tanks 1a and 1b. The anoxic tank comprises first and second anoxic tanks 2a and 2b. The aerobic tank comprises first and second aerobic tanks 3a and 3b. The wastewater purification apparatus of the present invention returns the active sludge settled in the setting tank 5 to the aerobic tank, while the conventional wastewater purification apparatus using the A2/O method returns the active sludge to the anaerobic tank.

The raw wastewater enters the anaerobic tank. The

wastewater is mixed and organisms (BOD) therein are removed with phosphorus accumulating organisms (PAOs). Thereby, phosphorus (PO4--P) is released and the phosphorus level in the tank is increased.

The wastewater treated in the anaerobic tank enters the anoxic tank, and then is mixed with a mixer. Thereby, in the anoxic tank, nitrogen and organisms is removed by denitrifying bacteria.

The wastewater treated in the anoxic tank partly enters the aerobic tank and partly returns to the anaerobic tank through a wastewater return line. As the NOx removed wastewater from the anoxic tank returns to the anaerobic tank, there hardly occurs inhibition of phosphorus release caused by NOx in the anaerobic tank and thus, the final phosphorus removal efficiency is enhanced. Besides, the internally returned wastewater contains PAOs, which are reused in the anaerobic tank to release a large amount of phosphorus and make the aerobic tank absorb an excess of phosphorus, thereby removal of the phosphorus is caused. A compressed air is blown from the bottom of the aerobic tank to supply oxygen to the aerobic tank and thereby remove residual organisms. Also, the ammonium nitrogen is converted to NOx by nitrate bacteria and internally returned to the anoxic tank for denitrification with denitrifying bacteria. The wastewater treated at the aerobic tank partly returns to the anoxic tank to remove nitrogen and partly enters the clarifier 5.

The clarifier 5, in which sludge is settled, discharges the purified water and returns part of the active sludge to the aerobic tank via a sludge return line.

FIG.2 is a plan view for illustrating a dissolved oxygen lowering tank, according to a preferred embodiment of the present invention, which is applied to the wastewater purification apparatus shown in FIG. 1.

The wastewater returned from the aerobic tank to the anoxic tank is allowed to pass through a dissolved oxygen lowering tank 4a during the returning process to lower the dissolved oxygen in the returned wastewater and thereby enhance the treatment efficiency in the anoxic tank.

The dissolved oxygen lowering tank 4a is illustrated to be installed at the corner in the aerobic tank in FIG. 2 but it can be also separately arranged. Unlike the aerobic tank into which compressed air is introduced, the dissolved oxygen lowering tank 4a has a return line installed at the bottom to pump up the treated wastewater in the vicinity of the bottom and transfer it to the anoxic tank.

According to a preferred embodiment of the present invention, the height of the wall of the dissolved oxygen lowering tank 4a is a little bit smaller than the water level in the aerobic tank so as to introduce the wastewater from the aerobic tank into the dissolved oxygen lowering tank 4a, and a return line is arranged at the bottom of the dissolved oxygen

lowering tank 4a to pump up the wastewater from the bottom with a pump. Thereby, the wastewater is spontaneously introduced into the dissolved oxygen lowering tank 4a and gradually move down the dissolved oxygen lowering tank 4a. As no compression air is injected into the dissolved oxygen lowering tank 4a, the dissolved oxygen in the wastewater decreases while the wastewater move down the dissolved oxygen lowering tank 4a. Accordingly, the dissolved oxygen in the wastewater becomes almost zero when the wastewater enters the anoxic tank.

NOx is used as an electron receptor in the denitrification stage, in which it is prevalent to use the dissolved oxygen in the aspect of energy production, thereby the nitrogen removal efficiency is deteriorated. Thus the use of the dissolved oxygen lowering tank 4a eliminates introduction of dissolved oxygen into the anoxic tank and thereby enhance the nitrogen removal efficiency.

Nozzles are provided at the ends of the return line connected from the dissolved oxygen lowering tank 4a to the anoxic tank and the wastewater return line connected from the anoxic tank to the anaerobic tank, so that the wastewater returned by pumping is sprayed into the anoxic tank and the anaerobic tank for mixing, without any separate mixing apparatus.

FIG. 3 is a plan view for illustrating a dissolved oxygen

lowering tank according to another preferred embodiment of the present invention.

In the wastewater purification apparatus shown in FIG. 2, the substrate contained in the wastewater is almost used up while passing through the anaerobic tank, the anoxic tank and the aerobic tank and thus, becomes insufficient to oxidize microorganisms. In such a case, there occurs a deterioration of the dissolved oxygen lowering efficiency at the dissolved oxygen lowering tank 4a, and hence the nitrogen and phosphorus removal efficiencies in the entire arrangement. In another aspect, the retention time in the dissolving oxygen lowering tank 4a for lowering the dissolved oxygen of the wastewater returned to the anoxic tank below a threshold value has to be too long and thus, an increased volume of the dissolved oxygen lowering tank 4a is required.

However, the wastewater provided from a zone positioned before the anoxic tank 2, for example, the raw wastewater or the wastewater in the anaerobic tank positioned before the anoxic tank 2 contains a lot of substrate. As illustrated in the figures, the present invention mixes, in the dissolved oxygen lowering tank 4b, the returned wastewater from the aerobic tank 3 positioned after the anoxic tank 2 with part of the wastewater containing a lot of substrate provided from a zone positioned before the anoxic tank 2 so as to lower the dissolved oxygen by way of physical mixing and microorganism-based biological

reactions.

The inlet on the left side of the dissolved oxygen lowering tank 4b shown in FIG. 3 shows the supply of part of the wastewater containing a lot of substrate, which may be the raw wastewater, the wastewater from the anaerobic tank, or both of them.

FIG. 4 is a plan view for illustrating the dissolved oxygen lowering tank shown in FIG. 3 applied to the wastewater purification apparatus shown in FIG. 1 according to another preferred embodiment of the present invention.

The wastewater entering the anoxic tank from the anaerobic tank and the wastewater returned to the anoxic tank from the aerobic tank are mixed in the dissolved oxygen lowering tank 4b to lower the dissolved oxygen and then enter the anoxic tank. Accordingly, the dissolved oxygen in the mixed wastewater is almost zero at the time when the wastewater enters the anoxic tank.

The designer may determine the ratio of the wastewater entering the dissolved oxygen lowering tank 4b out of the discharged wastewater of the anaerobic tank to the wastewater directly entering the anoxic tank without passing through the dissolved oxygen lowering tank 4b on the basis of the purpose of the design. That is, when all the wastewater discharged from the anaerobic tank enters the anoxic tank by way of the dissolved oxygen lowering tank 4b, the organism being

necessary to anaerobic denitrification is deficient and thus, effective denitrification is inhibited. Therefore, the distribution ratio of the discharged wastewater of the anaerobic tank entering the dissolved oxygen lowering tank 4b is closely related with the content of the organism in the raw wastewater.

According to a preferred embodiment of the present invention, the dissolved oxygen lowering tank 4b is provided on the internal return line from the aerobic tank to the anoxic tank, so that part of the discharged wastewater from the anaerobic tank (approximately 20 to 30 % of the raw wastewater) is mixed with the internal returned wastewater from the aerobic tank to rapidly lower the dissolved oxygen in the wastewater to less than 0.2 mg/*l* through the physical dilution and microorganism-based biological reaction. Thereby, inhibition of denitrification caused by the dissolved oxygen in the anoxic tank is minimized.

FIGS. 5a and 5b are diagrams showing the results of an experiment performed to measure the dissolved oxygen lowering characteristic in the dissolved oxygen lowering tank of the wastewater purification apparatus shown in FIG. 2, in which FIG. 5a shows the dissolved oxygen lowering characteristic of the wastewater returned to the aerobic tank in which the initial substrate still remains, and FIG. 5b shows the dissolved oxygen lowering characteristic of the wastewater returned to the aerobic tank after the substrate is completely oxidized.

In order to measure the dissolved oxygen lowering

characteristic, the discharged wastewater from the aerobic tank internally returned to the anoxic tank from the aerobic tank was collected and the dissolved oxygen according to time in a batch reaction tank is measured. The experimental conditions are presented in Table 1.

Table 1

Item	MLSS Concentration (mg/l)	Temperature (C)
Experimental Condition	4500 ~ 5200	19 ~ 24 C

FIG. 5a is a graph showing the results of the experiment performed under the conditions presented in Table 1. As illustrated in the figure, a required retention time was about 30 minutes. It is considered that the difference in the slope of the decrease in the dissolved oxygen results from the difference in the initial concentration of the substrate.

To examine the relationship between the decrease in the dissolved oxygen and the initial concentration of the substrate, an experiment to measure the dissolved oxygen lowering characteristic was performed after the complete oxidization of the initial substrate. The experimental conditions are presented in Table 2.

Table 2

Item	MLSS Concentration (mg/l)	Temperature (C)	NH3	CODcr
Experimental Condition	4500 ~ 5200	19 ~ 24	Below 1 mg/l	Below 15 mg/l

FIG. 5b is a graph showing the results of an experiment performed under the conditions presented in Table 2. As illustrated in the figure, completion oxidization of the substrate resulted in an increase of the dissolved oxygen to more than 7.0 mg/l and about 70 minutes was required to lower the dissolved oxygen to less than 0.2 mg/l. The dissolved oxygen in the aerobic tank operated in the actual site was maintained below 3 mg/l at maximum. Therefore, about 30 minutes was taken to lower the dissolved oxygen in the same manner as shown in FIG. 5a.

FIGS. 6a to 6j are diagrams showing the results of an experiment performed to measure the dissolved oxygen lowering characteristic in the dissolved oxygen lowering tank 4b of the wastewater purification apparatus shown in FIG. 4, while varying the mixing ratio of the wastewater from the anaerobic tank and the wastewater returned from the aerobic tank.

As described previously, the wastewater purification apparatus shown in FIGS. 5a and 5b requires about 30 minutes to decrease the dissolved oxygen. In order to shorten the retention time, the present invention lowers the dissolved

oxygen using the substrate oxidization method that involves addition of the substrate to the wastewater returned from the aerobic tank. In the most preferable method, as shown in FIG. 4, part of the discharged wastewater from the anaerobic tank that maintains the dissolved oxygen of less than 0.2 mg/*l* is mixed with the returned wastewater having a dissolved oxygen of 2 to 3 mg/*l* so as to lower the dissolved oxygen through physical mixing and microorganism-based oxidization of the substrate contained in the discharged water from the anaerobic tank.

Table 3 shows the experimental conditions used in an experiment performed to measure the dissolved oxygen lowering characteristic while mixing the discharged wastewater from the anaerobic tank with the wastewater returned to the aerobic tank.

Table 3

Item Reaction Tank	MLSS Concentration (mg/*l*)	DO Concentration (mg/*l*)	Temperature (C)
Anaerobic Tank	1200 ~ 1500	Below 0.1	14 ~ 16
Aerobic Tank	4800 ~ 5500	3.0 ~ 2.5	
Entire	3000 ~ 3500		

FIGS. 6a to 6j are graphs showing the dissolved oxygen lowering characteristic measured in an experiment under conditions presented in Table 3, in which the mixing ratio of the discharged wastewater from the anaerobic tank to the internally returned wastewater from the aerobic tank is 1:1 to 1:10.

A comparison of FIGS. 6a and 5a, the required time for lowering the dissolved oxygen was about 30 minutes before

mixing and about 4 minutes after the mixing, which resulted from not only the physical effect of mixing the discharged wastewater from the anaerobic tank to lower the dissolved oxygen but also the biological reaction related to microorganisms that oxidize a lot of substrate contained in the discharged wastewater from the anaerobic tank.

In order to determine an optimum mixing ratio of the discharged wastewater of the anaerobic tank to the internally returned wastewater from the aerobic tank based on the experimental results, an experiment was performed with the mixing ratio of the discharged wastewater from the anaerobic tank to the internally returned wastewater from the aerobic tank being varied in the range of 1:2 to 1:10. As a result, the maximum required time was about 6 minutes. It can be seen that mixing part of the discharged wastewater from the anaerobic tank as illustrated in FIG. 4 is preferred to retaining the internally returned wastewater for a predetermined time as illustrated in FIG. 1 to lower the dissolved oxygen.

To summarize the experimental results, the mixing ratio of the internally returned wastewater from the aerobic tank to the discharged wastewater from the anaerobic tank in the dissolved oxygen lowering tank is preferably less than 10, with the retention time of the wastewater in the dissolved oxygen lowering tank being at most10 minutes. It should be however noted that the mixing ratio and the retention time are not limited

to the above ranges so long as the retention time is shorter than 30 minutes of FIG. 5a.

FIGS. 7 to 12 are schematic plan views of a wastewater purification apparatus equipped with the dissolved oxygen lowering tank shown in FIG. 3 according to further another preferred embodiment of the present invention. The wastewater purification apparatus of FIG. 7 does not require a separate space for installation of the dissolved oxygen lowering tank unlike that of FIG. 4.

The wastewater purification apparatus of FIG. 8 is similar in structure to that of FIG. 4, with the exception that the returned wastewater from the aerobic tank, part of the raw wastewater and the wastewater from the anaerobic tank enter the dissolved oxygen lowering tank 4b. The wastewater purification apparatus of FIG. 9 is also similar in structure to that of FIG. 4, excepting that the returned wastewater from the aerobic tank and part of the raw wastewater enter the dissolved oxygen lowering tank 4b.

FIGS. 10, 11 and 12 are schematic diagrams showing examples of the dissolved oxygen lowering tank 4b shown in FIG. 3 applied to the conventional A2/O method, the conventional five-staged Bardenpho method, and the conventional UCT method, respectively.

FIG. 13 is a schematic plan view of a wastewater purification apparatus having separate walls 8 according to

further another preferred embodiment of the present invention. As illustrated in the figure, a plurality of separate walls 8 are vertically formed in the anaerobic tank 1 and the anoxic tank 2 so as to cause a plug flow in the anaerobic tank 1 and the anoxic tank 2.

Each of the separate walls 8 has one side being in close contact with one side wall of the anaerobic tank 1 or the anoxic tank 2, and the other side being somewhat apart from the other side wall of the anaerobic tank 1 or the anoxic tank 2. Also, the plural separate walls 8 are arranged in zigzag to cause the plug flow in the anaerobic tank 1 and the anoxic tank 2.

The plug flow is advantageously adequate for inducing endogenous respiration of the microorganisms and thereby enhancing the contaminant removal efficiency. Thus such a plug flow enhances the treatment rate in the anaerobic tank 1 or the anoxic tank, and hence the treatment efficiency.

FIG. 14 is a plan view of a wastewater purification apparatus shown in FIG. 2 having separate walls 8 according to further another preferred embodiment of the present invention.

FIGS. 15a and 15b are schematic views showing a method for mounting a PE panel constituting the separate walls 8, the dissolved oxygen lowering tanks 4a and 4b, and partition walls according to further another preferred embodiment of the present invention.

As illustrated in FIG. 15a, the PE panel 10 arranged in the

tanks provides the dissolved oxygen lowering tanks 4a and 4b, the separate walls 8 and partition walls in a relatively simple installation work. Two angles 9 for fixing the PE panel are separated at a predetermined distance from each other and fixed on the inner wall of the tank. The PE panel 10 is inserted between them and then, caulking the joint is performed to complete an installation of the dissolved oxygen lowering tanks 4a and 4b, the separate walls 8 and the partition walls. The use of the PE panel 10 allows rapid installation and the PE panel 10 has excellent properties including water proof and durability. It can be seen from FIG. 15b that the PE panel 10 can be used or a single large member but as a plurality of wide and thin members 10a that are vertically connected in installation. This makes it possible to regulate the heights of the dissolved oxygen lowering tanks 4a and 4b.

What is claimed is:

1. An apparatus for purifying wastewater comprising:

an anaerobic tank 1 for treating the wastewater with anaerobic bacteria;

an anoxic tank 2 for treating the wastewater from the anaerobic tank 1 with denitrifying bacteria and then returning part of the wastewater to the anaerobic tank 1;

an aerobic tank 3 for treating the wastewater from the anoxic tank 2 with aerobic bacteria and then returning part of the wastewater to the anoxic tank 2; and

a clarifier 5 for settling the wastewater from the aerobic tank 3, discharging a purified water, and returning part of a sediment to the aerobic tank 3 through a return line 6.

2. The apparatus for purifying wastewater as claimed in claim 1, wherein the anaerobic tank, the anoxic tank and the aerobic tank are formed by arranging partition walls with a PE panel in a single tank.

3. The apparatus for purifying wastewater as claimed in claim 1, wherein the wastewater returned from the aerobic tank 3 to the anoxic tank 2 is introduced in halfway into a dissolved oxygen lowering tank 4 to decrease the dissolved oxygen, and then returned to the anoxic tank 2.

4. The apparatus for purifying wastewater as claimed in claim 3, wherein part of the wastewater prior to entering the anaerobic tank or part of the wastewater from the anaerobic tank is additionally introduced into the dissolved oxygen lowering tank 4.

5. An apparatus for purifying wastewater, which has an anaerobic tank, an anoxic tank, an aerobic tank, and a clarifier, comprising a dissolved oxygen lowering tank for receiving the wastewater returned from the aerobic tank positioned after the anoxic tank and part of the wastewater from a zone positioned before the anoxic tank to decrease the dissolved oxygen, and then introducing the received wastewaters into the anoxic tank.

6. The apparatus for purifying wastewater as claimed in claim 5, wherein the wastewater from the zone positioned before the anoxic tank is at least one of the raw wastewater and the wastewater from the anaerobic tank positioned before the anoxic tank.

7. The apparatus for purifying wastewater as claimed in claim 5 or 6, wherein the anaerobic tank positioned before the anoxic tank and the anoxic tank have a wastewater return line for returning part of the wastewater from the anoxic tank to the anaerobic tank positioned before the anoxic tank, and the

aerobic tank after the anoxic tank and the clarifier positioned after the anoxic tank have a sludge return line for returning part of the sediment from the clarifier positioned after the anoxic tank to the aerobic tank positioned after the anoxic tank.

8. The apparatus for purifying wastewater as claimed in any one of claims 3 to 6, additionally comprising nozzles arranged at an inlet through which the wastewater from the dissolved oxygen lowering tank 4 is introduced into the anoxic tank.

9. The apparatus for purifying wastewater as claimed in any one of claims 1 to 6, additionally comprising a plurality of separate walls vertically provided in zigzag inside the anaerobic tank and the anoxic tank, wherein each of the separate walls has one side thereof being in close contact with one side wall of the anaerobic tank or the anoxic tank, and the other side thereof being apart from the other side wall of the anaerobic tank or the anoxic tank, thereby causing a plug flow of the wastewater in the anaerobic tank and the anoxic tank.

10. The apparatus for purifying wastewater as claimed in claim 9, wherein the dissolved oxygen lowering tank or the separate walls are manufactured by fixing PE panel fixing angles in an inner side wall of the aerobic tank 3, the anaerobic

tank 3 or the anoxic tank 2, inserting a PE panel between the PE panel fixing angles, and then caulking a joint.

11. The apparatus for purifying wastewater as claimed in claim 2 or 10, wherein the PE panel is formed by connecting a plurality of PE panel pieces.

12. A method for purifying wastewater comprising the steps of:

treating the wastewater introduced into an anaerobic tank with anaerobic bacteria;

introducing the wastewater from the anaerobic tank into an anoxic tank for treatment with denitrifying bacteria, and then returning part of the wastewater to the anaerobic tank;

introducing the wastewater from the anoxic tank into an aerobic tank for treatment with aerobic bacteria, and then returning part of the wastewater to the anoxic tank; and

settling the wastewater from the aerobic tank, and returning part of a sediment to the aerobic tank.

13. The method for purifying wastewater as claimed in claim 12, wherein the wastewater returned from the aerobic tank 3 to the anoxic tank 2 is introduced in halfway into a dissolved oxygen lowering tank 4 to decrease the dissolved oxygen, and then returned to the anoxic tank 2.

14. A method for purifying wastewater, which is to treat the wastewater using an apparatus for purifying wastewater having an anaerobic tank, an anoxic tank, an aerobic tank, and a clarifier, the method comprising the steps of:

introducing, into a dissolved oxygen lowering tank, part of the wastewater from a zone positioned before the anoxic tank and the wastewater returned from the aerobic tank positioned after the anoxic tank to decrease the dissolved oxygen: and

introducing the wastewater from the dissolved oxygen lowering tank into the anoxic tank.

Fig. 1

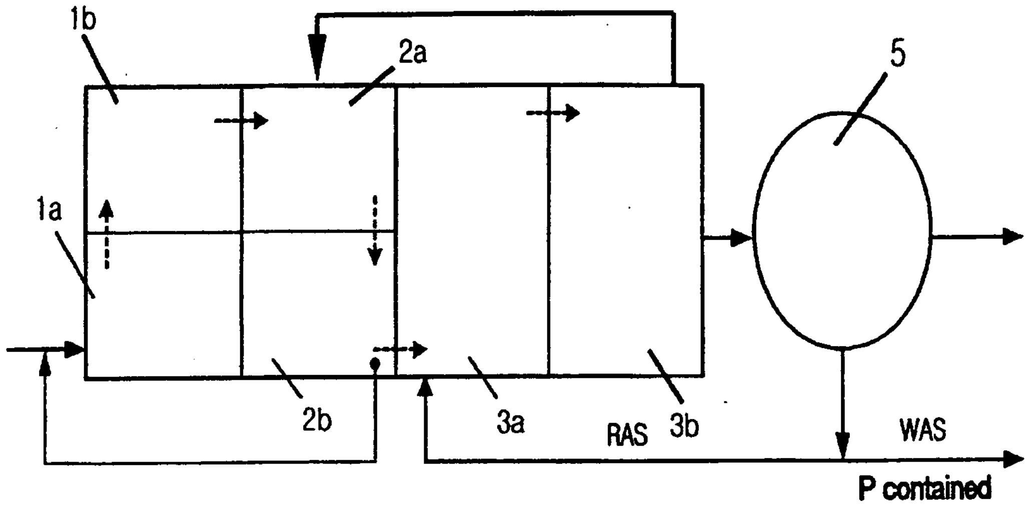

1b
2a
5
1a
2b
3a
RAS
3b
WAS
P contained

Fig. 2

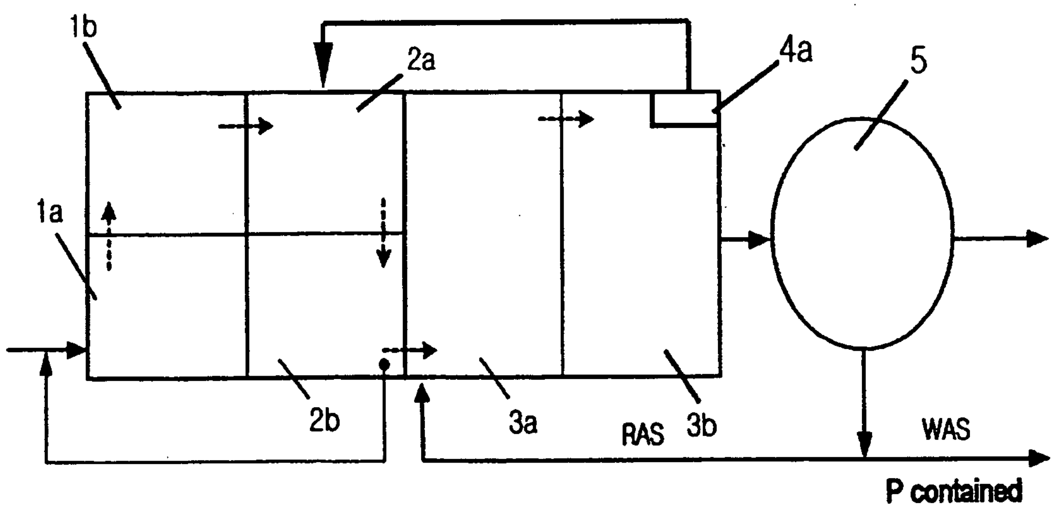

1b
2a
4a
5
1a
2b
3a
RAS
3b
WAS
P contained

Fig. 3

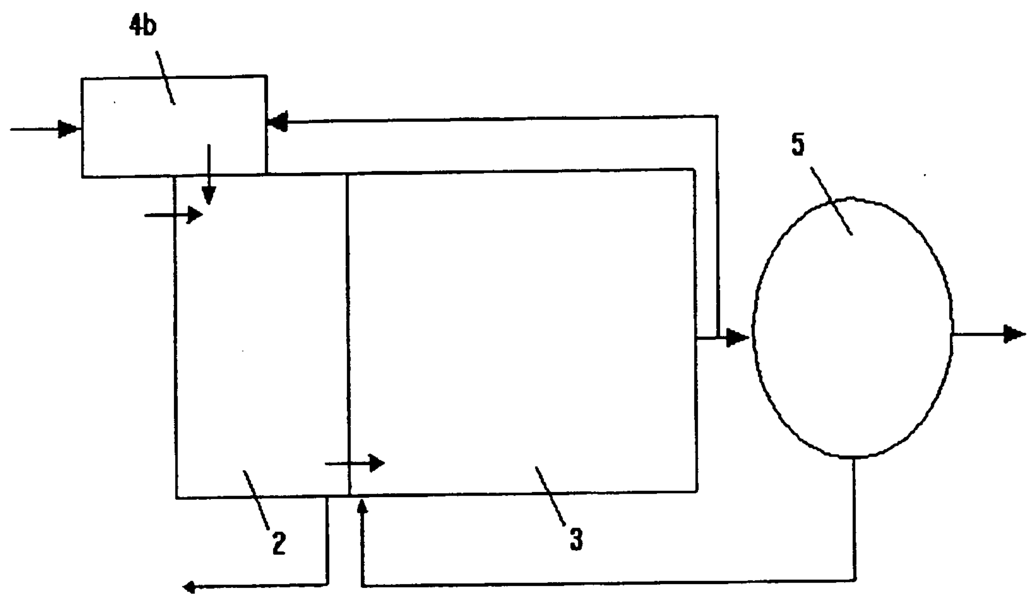


Fig. 4

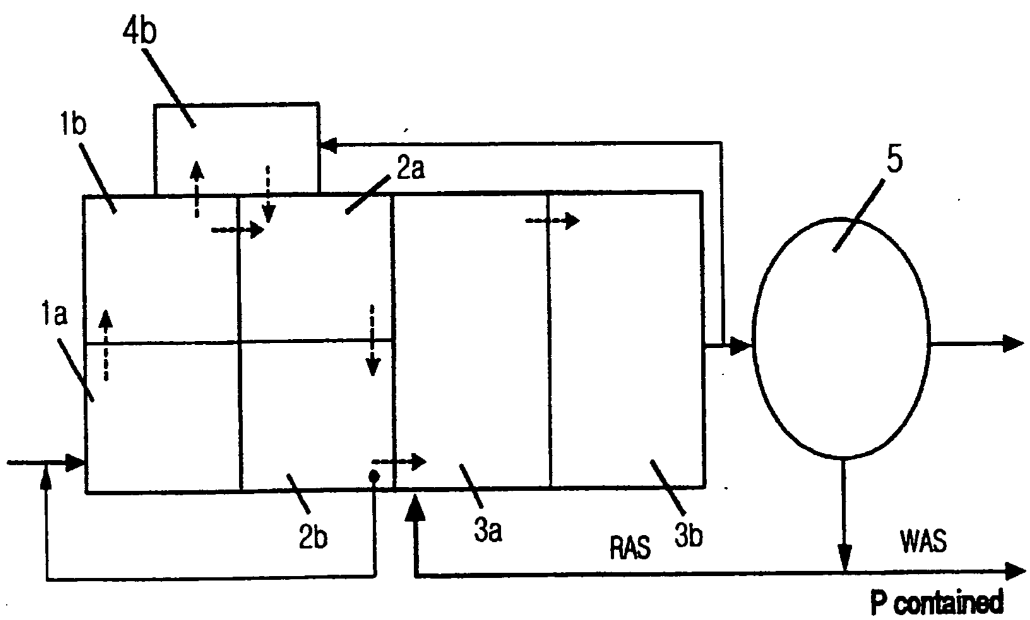


Fig. 5 a

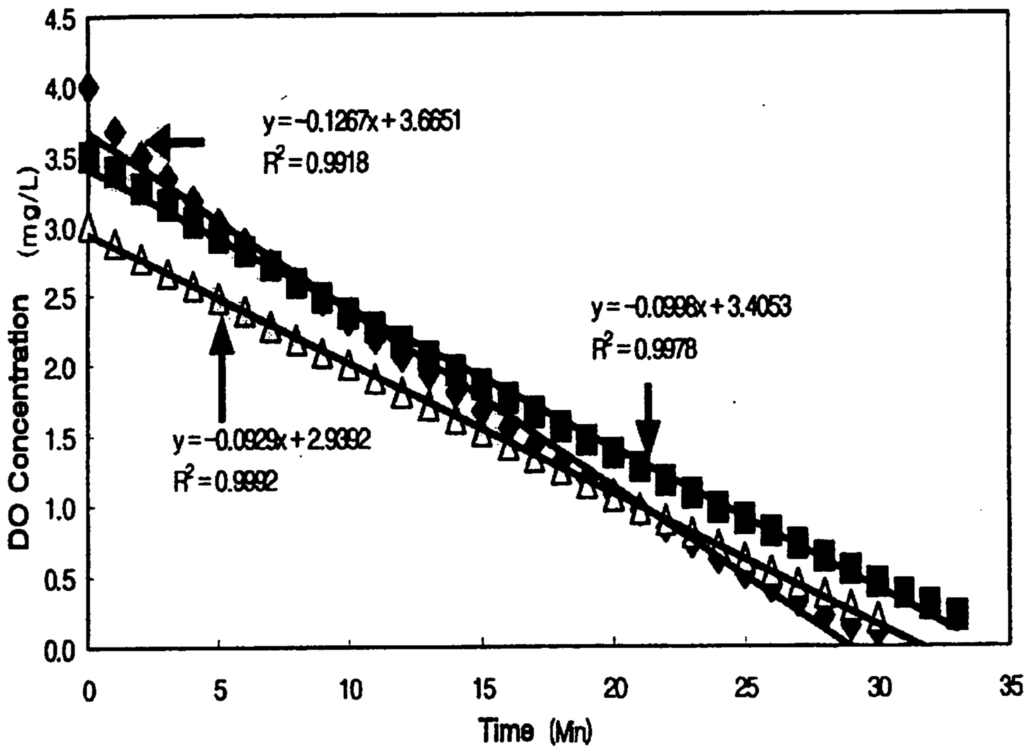

y=-0.1267x+3.6651
R2=0.9918
y=-0.0998x+3.4053
R2=0.9978
y=-0.0929x+2.9392
R2=0.9992
DO Concentration (mg/L)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
Time (Min)

Fig. 5 b

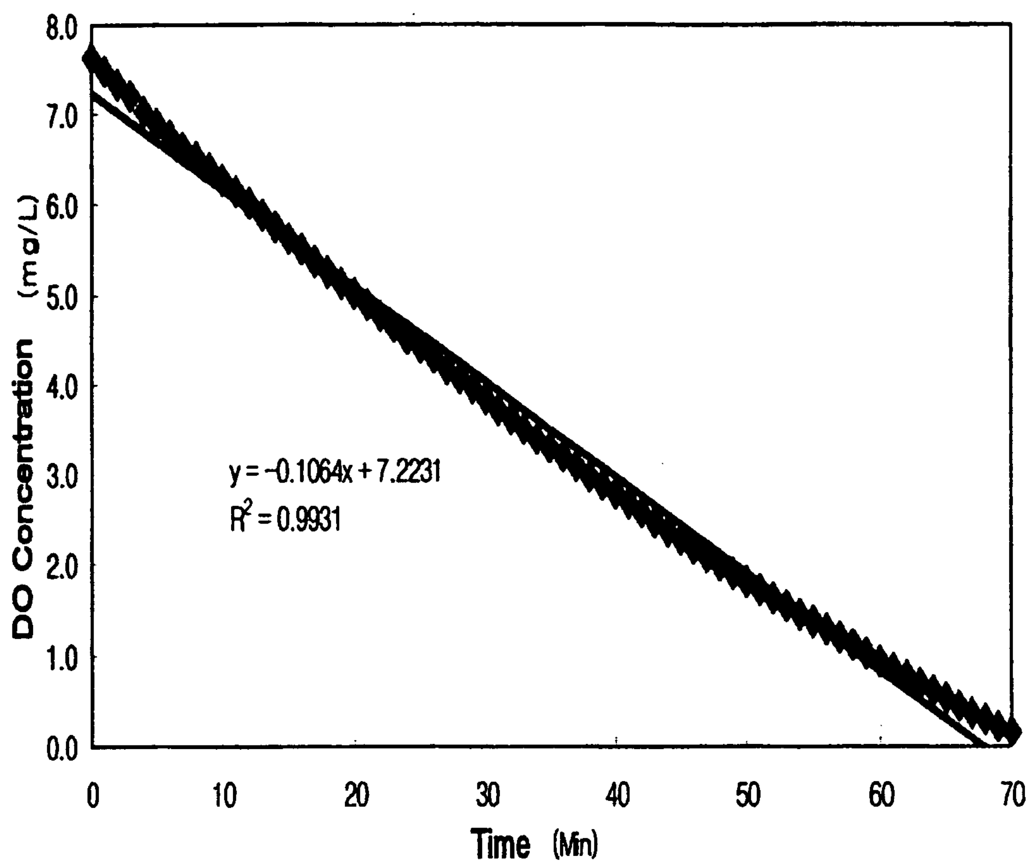

8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
DO Concentration (mg/L)
y = -0.1064x + 7.2231
R2 = 0.9931
0
10
20
30
40
50
60
70
Time (Min)

Fig. 6 a

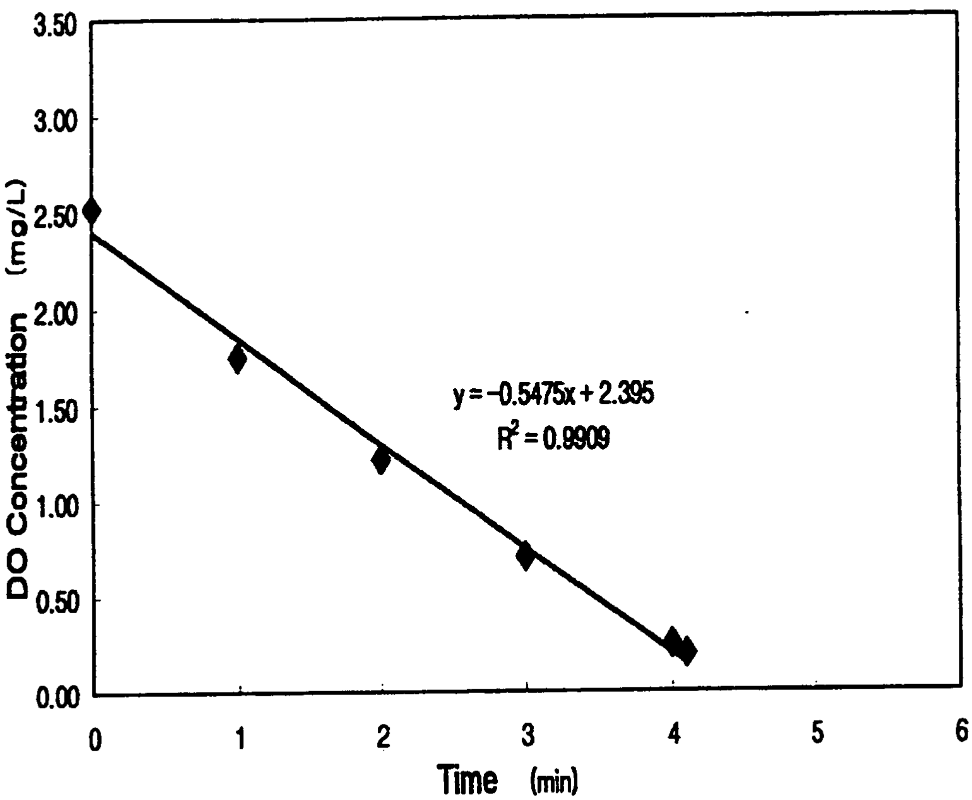

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
y = -0.5475x + 2.395
R² = 0.9909
0
1
2
3
4
5
6
Time (min)

Fig. 6 b

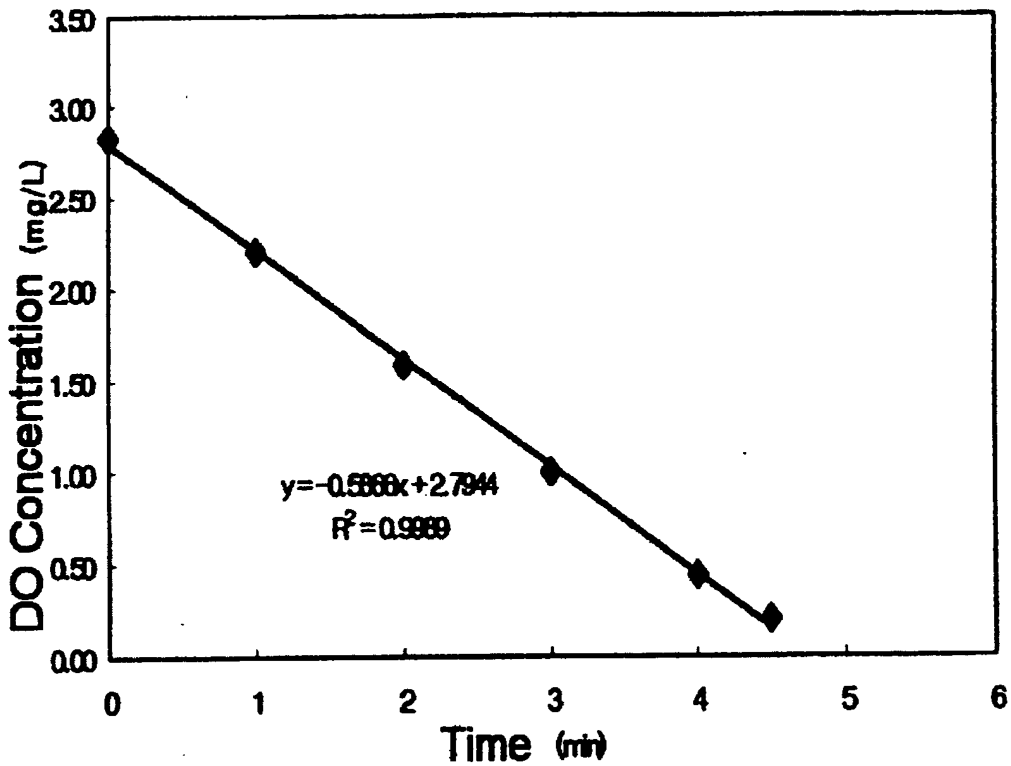

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
y=-0.5866x+2.7944
R2=0.9989
0
1
2
3
4
5
6
Time (min)

Fig. 6 c

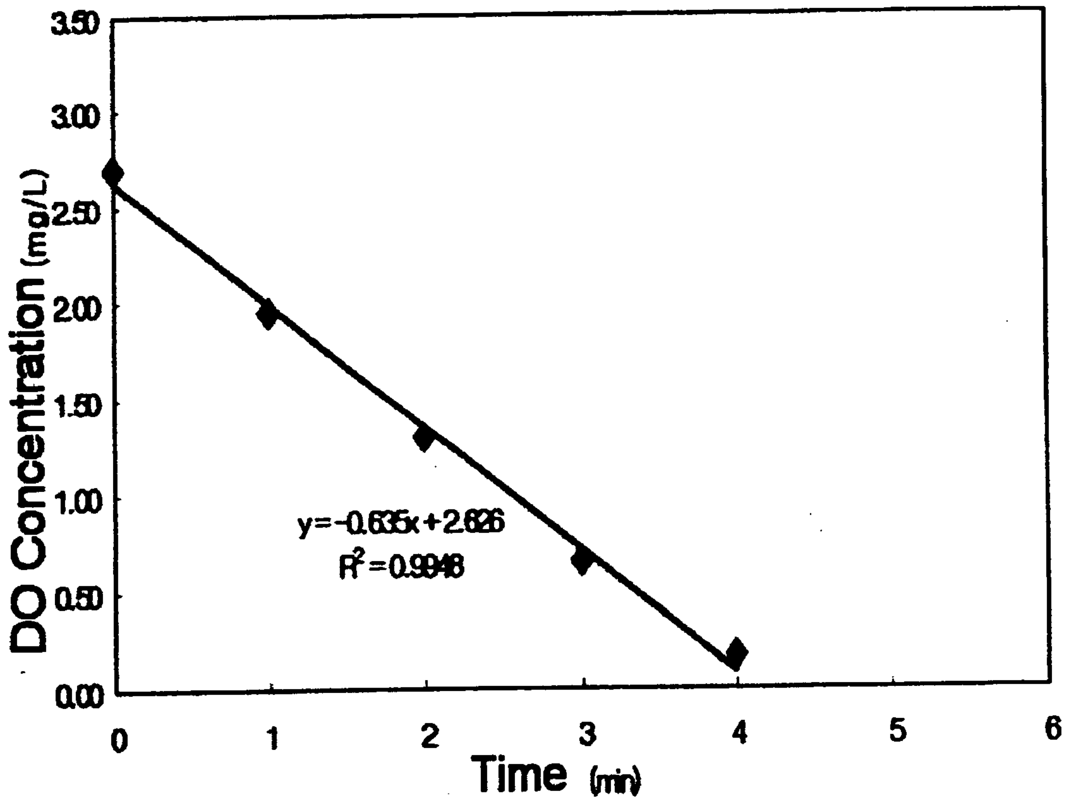

DO Concentration (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
1
2
3
4
5
6
Time (min)
y=-0.635x+2.626
R²=0.9948

Fig. 6 d

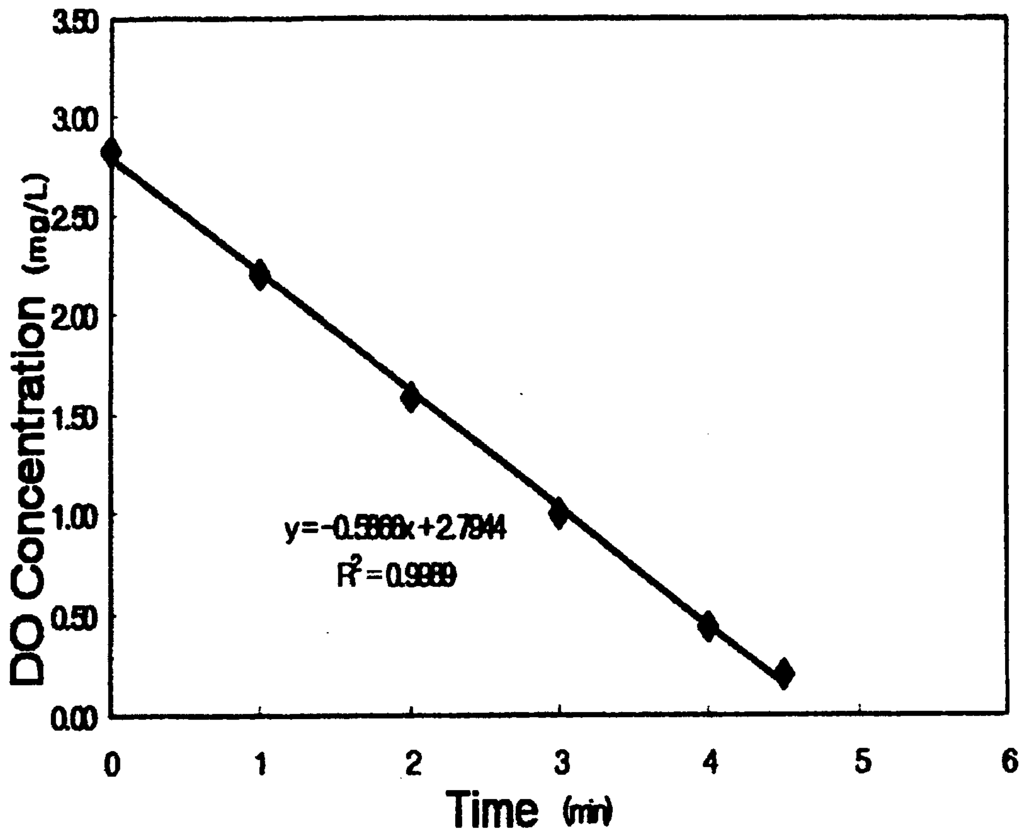

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
y=-0.5868x+2.7944
R2=0.9989
0
1
2
3
4
5
6
Time (min)

Fig. 6 e

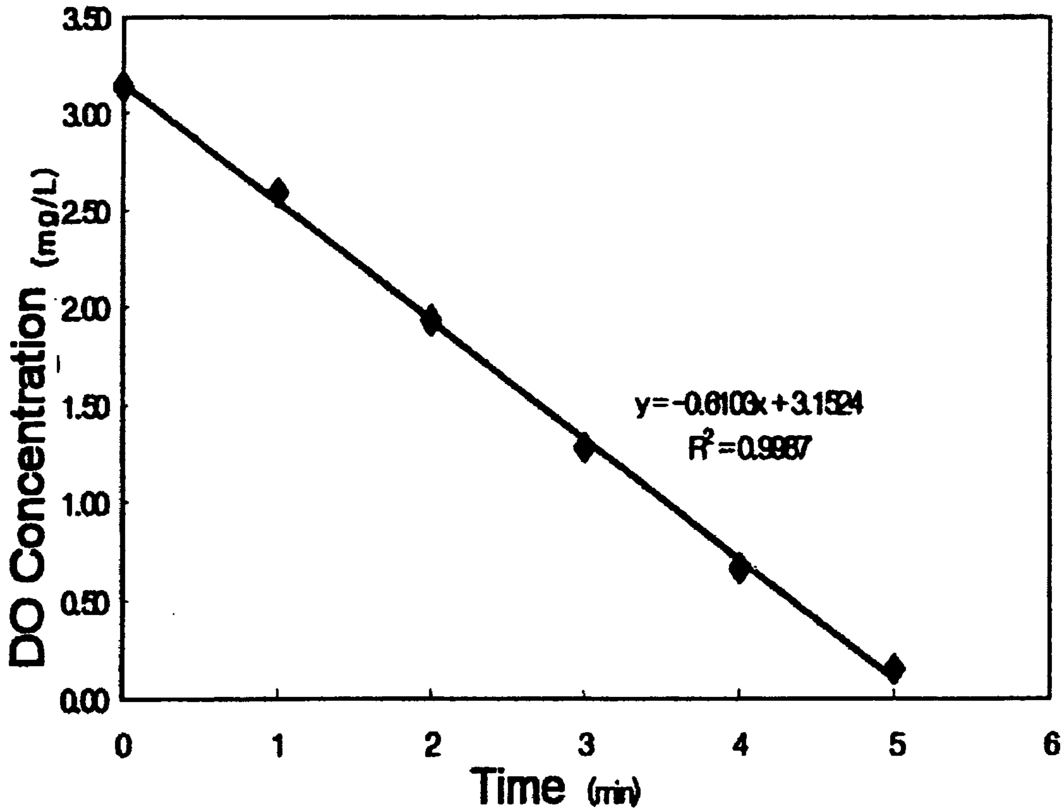

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
y=-0.6103x+3.1524
R²=0.9987
0
1
2
3
4
5
6
Time (min)

Fig. 6 f

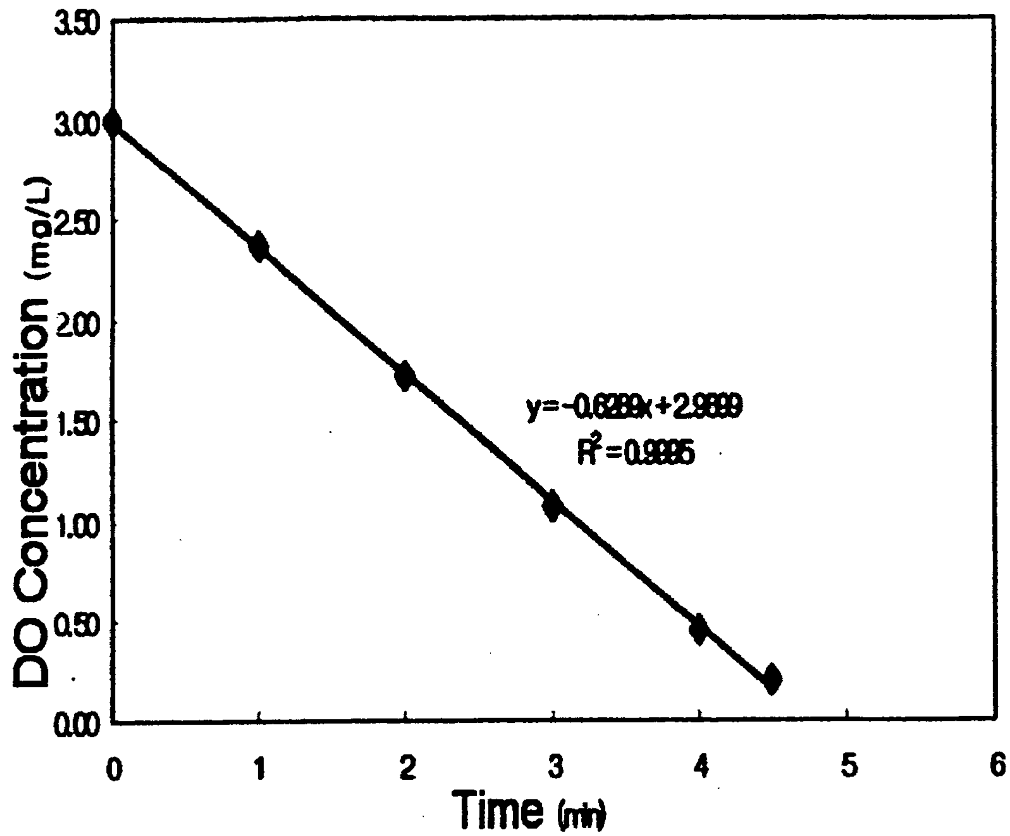

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
y=-0.6289x+2.9899
R²=0.9995
0
1
2
3
4
5
6
Time (min)

Fig. 6 g

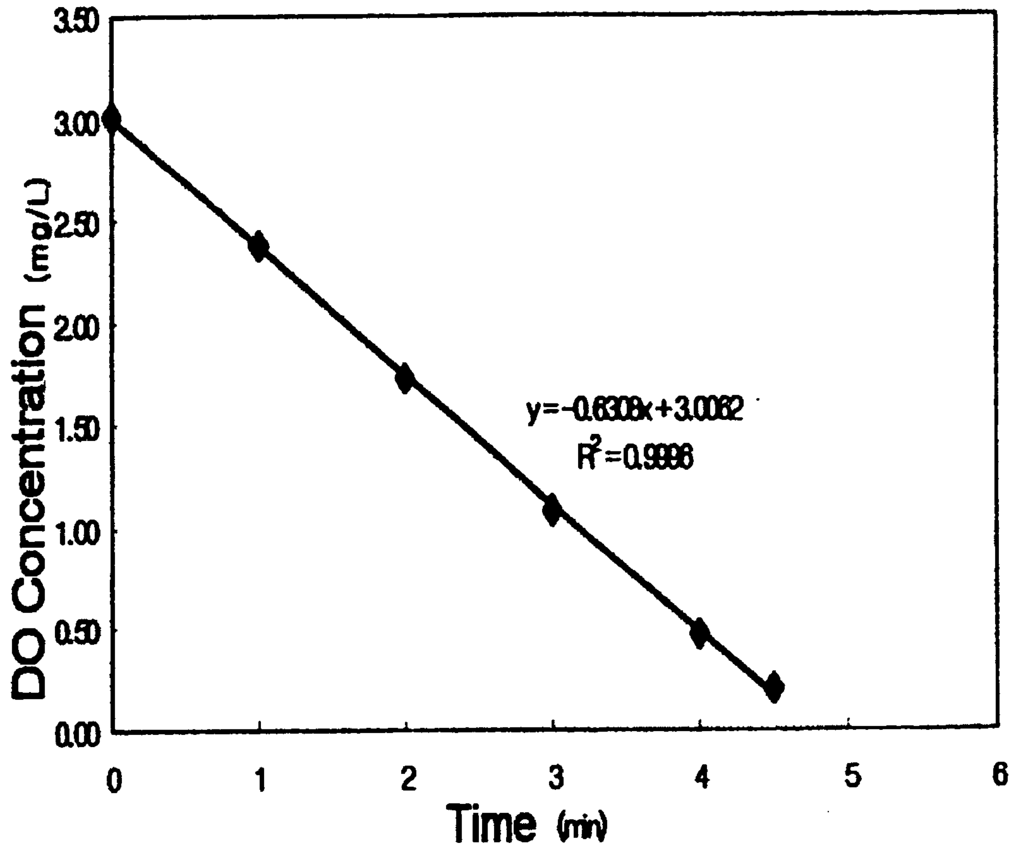

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
y=-0.6308x+3.0062
R2=0.9996
0
1
2
3
4
5
6
Time (min)

Fig. 6 h

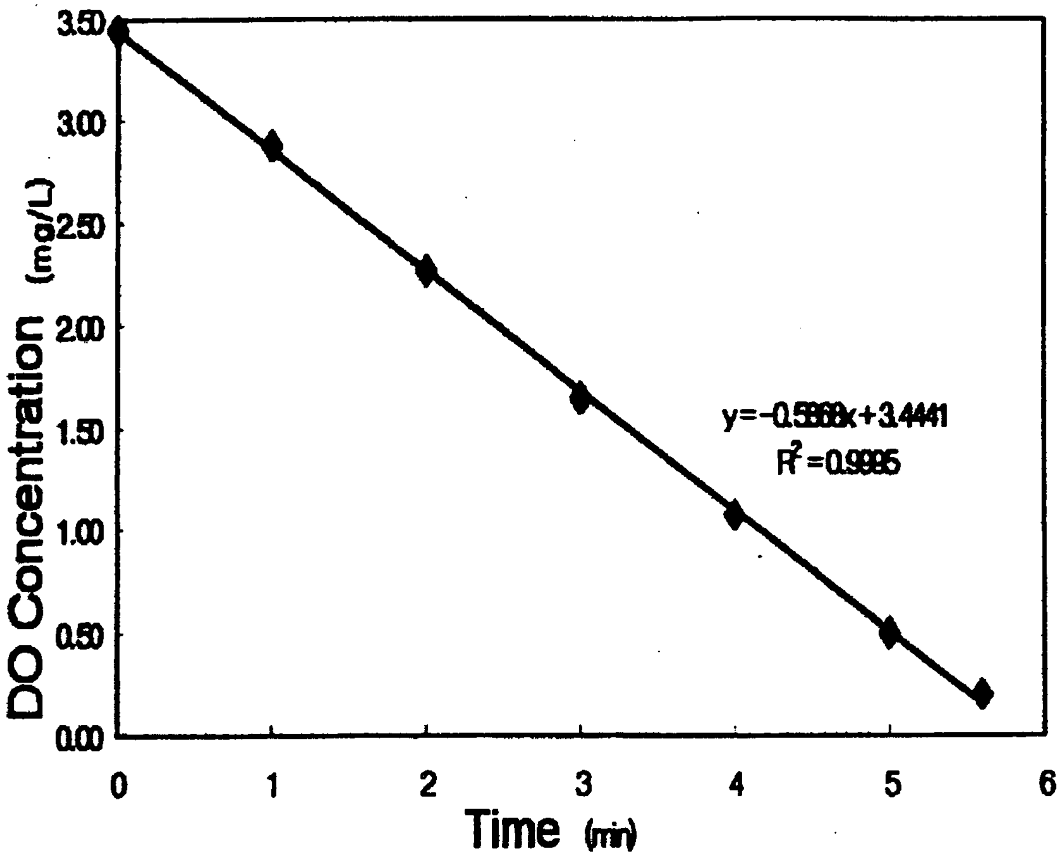

DO Concentration (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
1
2
3
4
5
6
Time (min)
y=-0.5868x+3.4441
R2=0.9995

Fig. 6 i

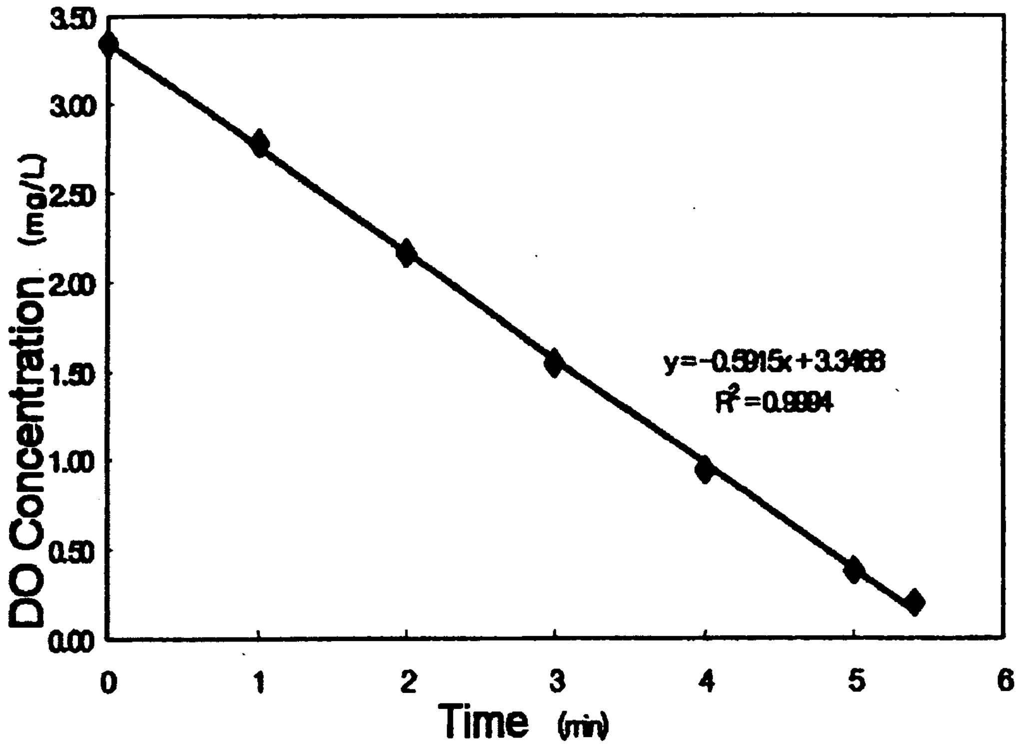

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
0
1
2
3
4
5
6
Time (min)
y=-0.5915x+3.3468
R²=0.9994

Fig. 6 j

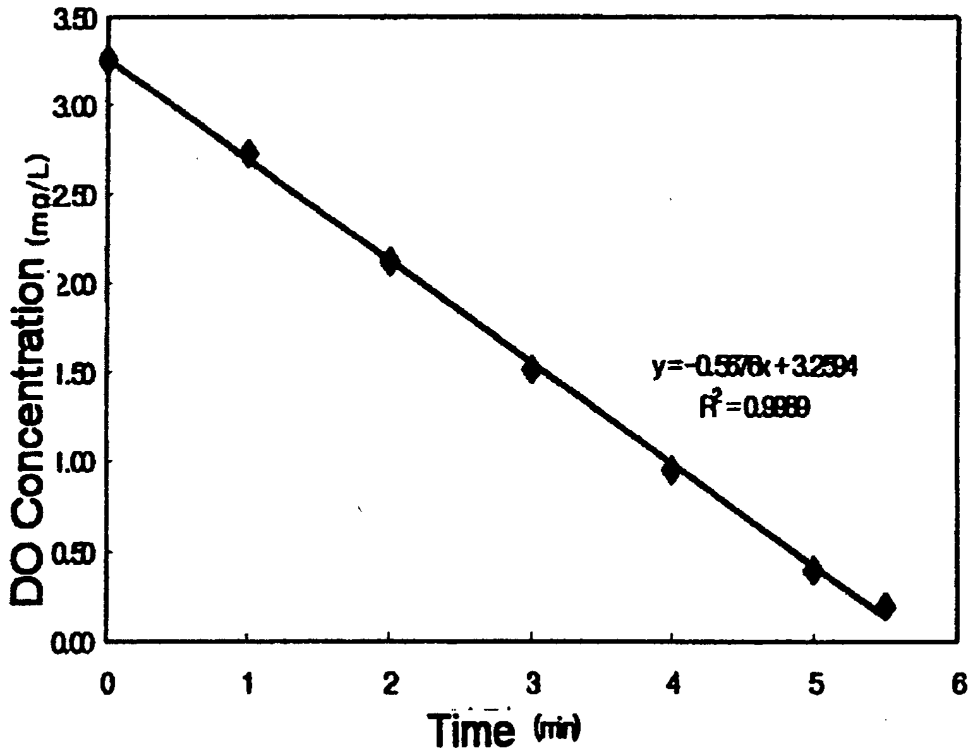

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO Concentration (mg/L)
y=-0.5576x+3.2594
R2=0.9989
0
1
2
3
4
5
6
Time (min)

Fig. 7

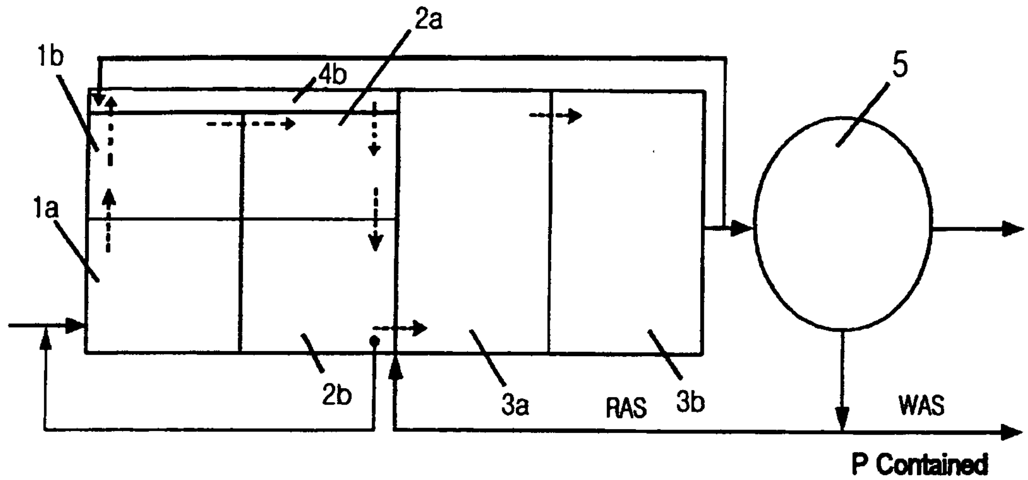


Fig. 8

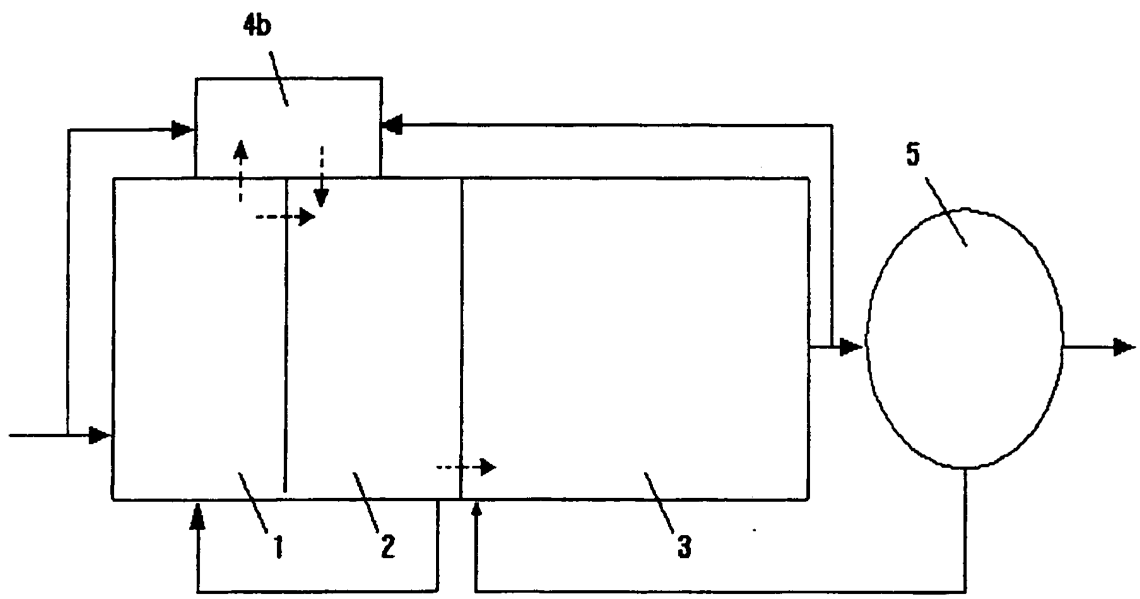


Fig. 9

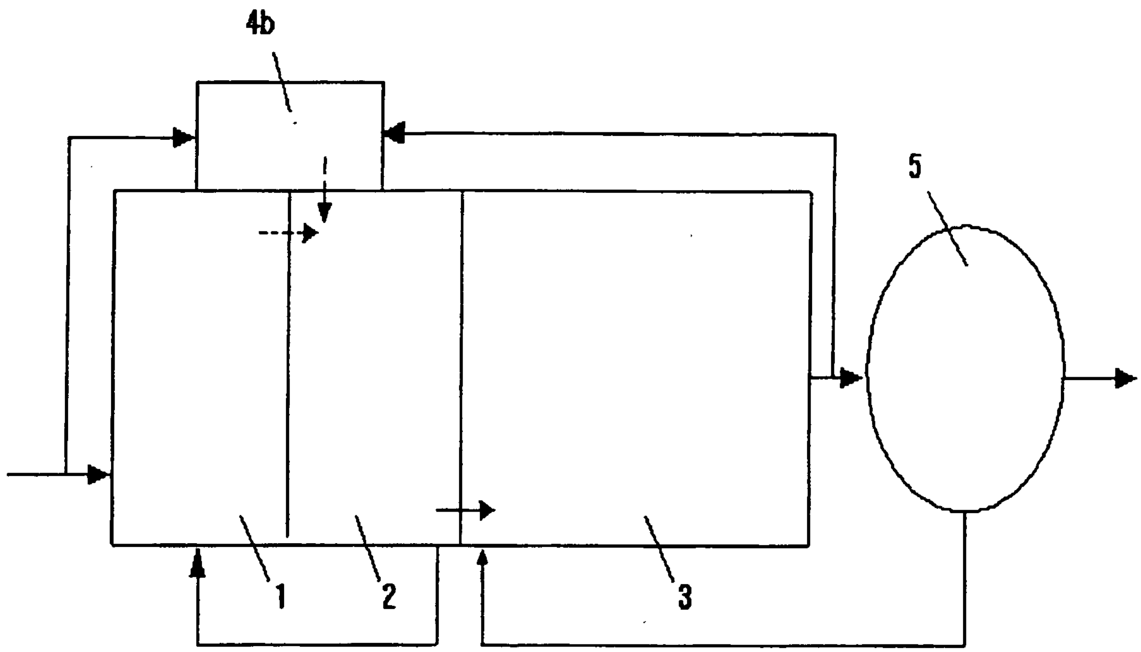


Fig. 10

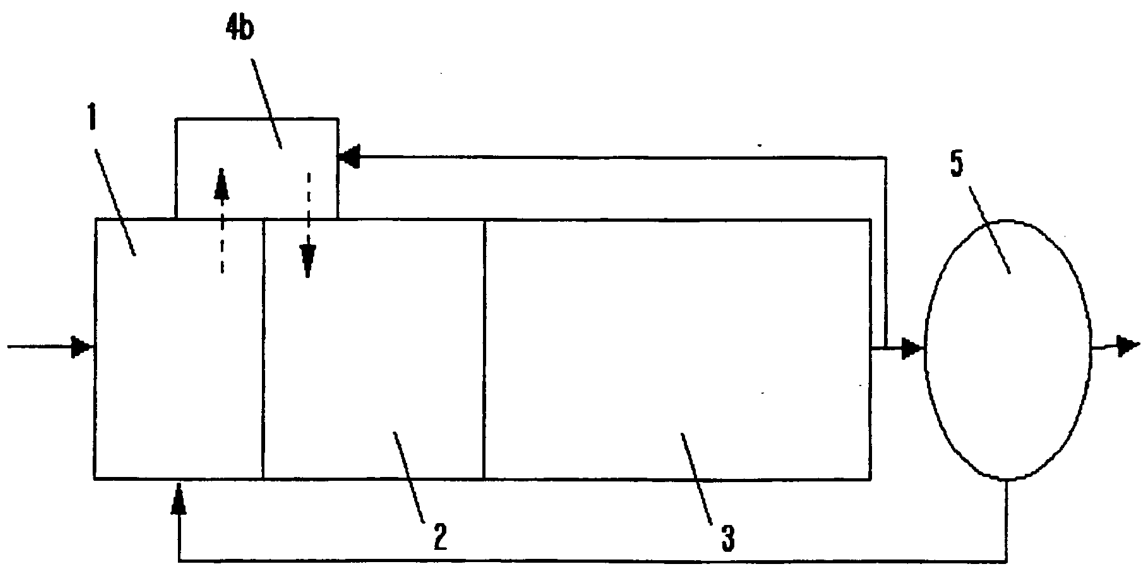


Fig. 11

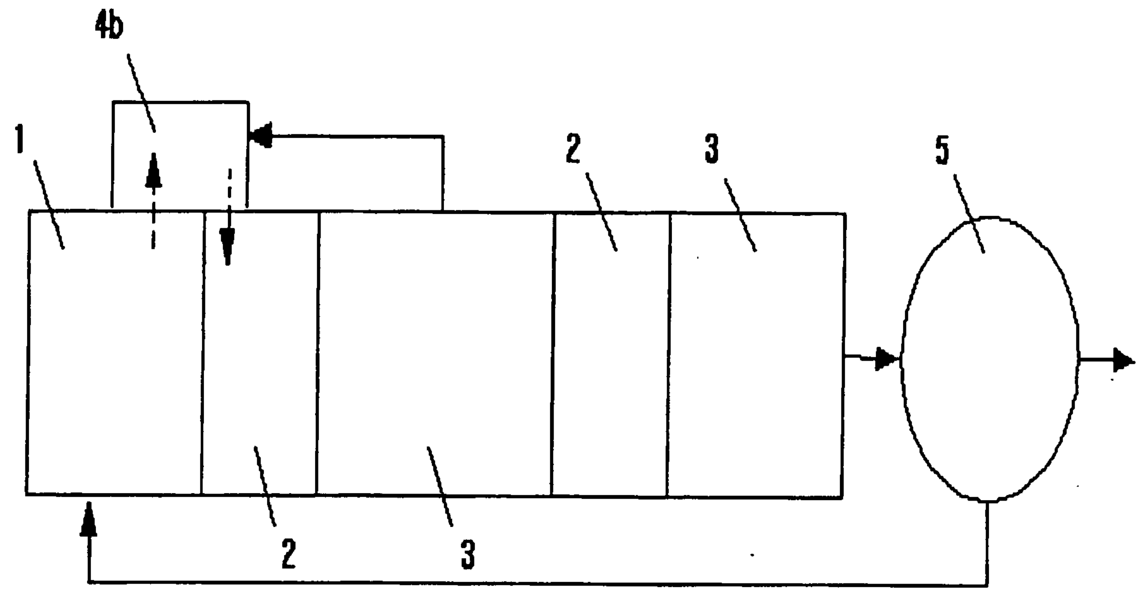


Fig. 12

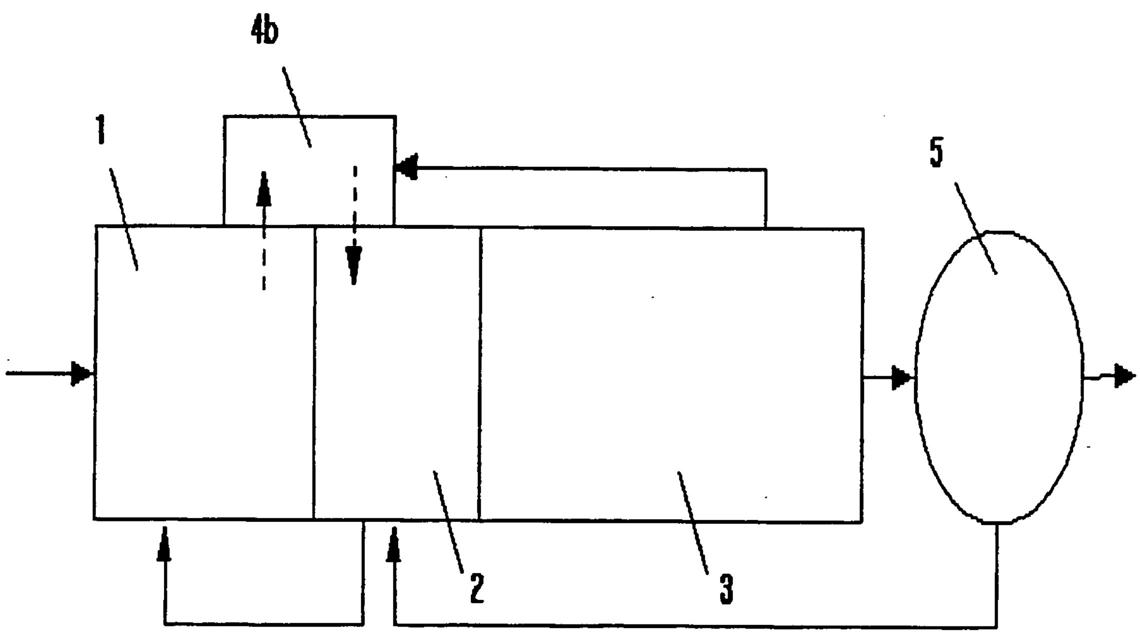


Fig. 13

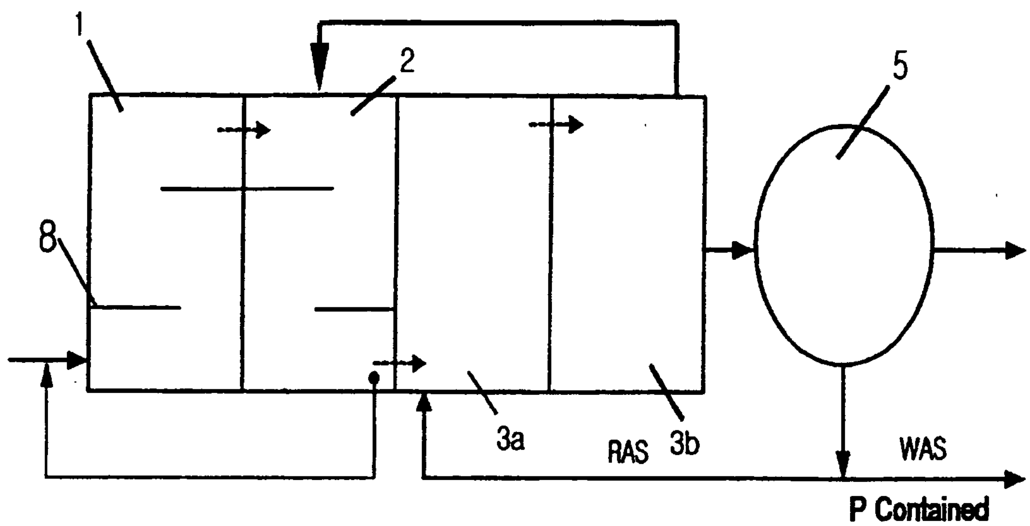

1
2
5
8
3a
RAS
3b
WAS
P Contained

Fig. 14

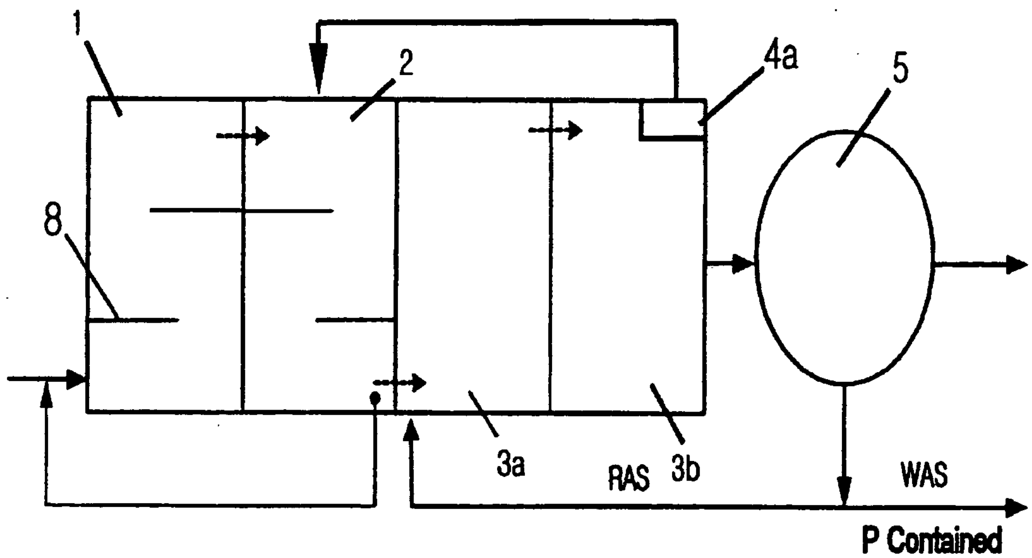

1
2
4a
5
8
3a
RAS
3b
WAS
P Contained

Fig. 15a

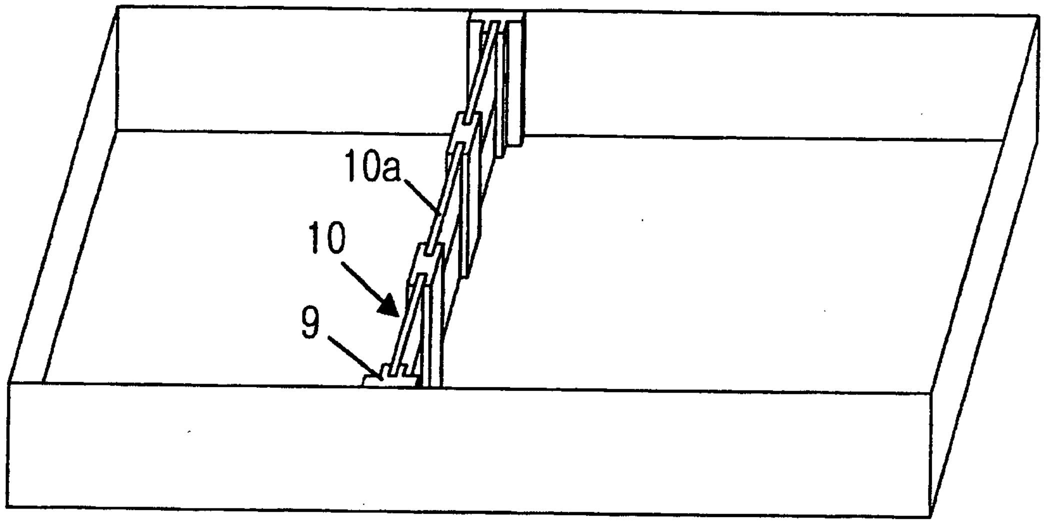
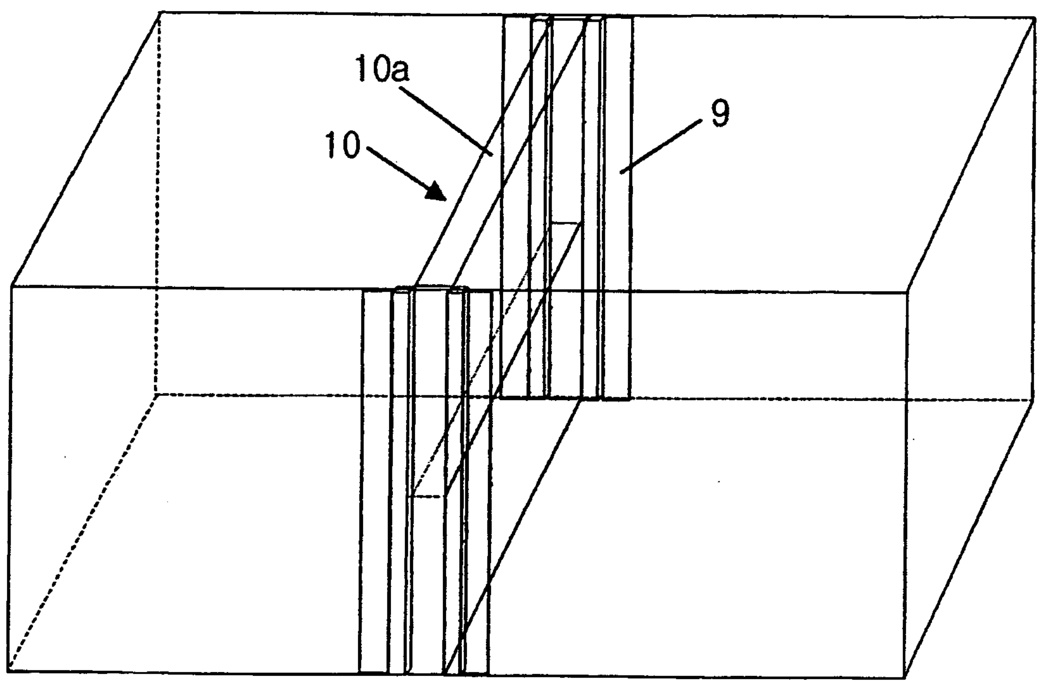


Fig. 15b



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/00356

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 C02F 9/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 C02F

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and applications for inventions since 1975
Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

NPS, IPN, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 1997-69904 A(Jung, Chung Hyuk) 7 November 1997 see the whole document.	1
A	US 4,394,268 A(John H. Reid) 19 July 1983 see the whole documemt.	1
A	JP 08-155488 (Matsusita Denki Industrial company) 18 June 1996 see the whole document.	1
A	JP 05-337496(Matsusita Denki Industrial company) 21 December 1993 see the whole document	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevence
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 JUNE 2001 (20.06.2001)	21 JUNE 2001 (21.06.2001)

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, Dunsan-dong, Seo-gu, Daejeon Metropolitan City 302-701, Republic of Korea Facsimile No. 82-42-472-7140	LEE, Su Hyoung Telephone No. 82-42-481-5597

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR01/00356

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 1997-69904	07.11.1997	None	
US 4,394,268	19.07.1983	None	
JP08-155488	18.06.1996	None	
JP05-337496	21.12.1993	None	